

# NUTS & BOLTS

By KC HOSLER

## Intelligent Facility Design A Question of Balance

**A**quaculture systems are dynamic, living entities that are inherently out of balance. Fish grow, feeding rates change, and fish are harvested or graded resulting in an ever-changing biomass and nutrient load on the system. Successful management of such a dynamic system is an act of balancing production levels, fish health, water quality, and of course operating costs.

Designing an aquaculture facility is also a balancing act, one in which the designer must make choices and compromises in finding an optimum solution. The designer is faced with the conflicting objectives of minimizing capital and operating costs, and risk, while maximizing production and quality. The goal of intelligent system design is to strike a balance among these objectives that results in the lowest total cost to the owner while optimizing productivity

and profitability. The success of a facility ultimately requires defining this balance at the business planning stage, and using it as a guideline throughout the design process.

The balancing act begins at the initiation of the project when size and production capabilities are first decided. Design criteria such as system volume, culture density, and feed rates, to name a few, form the basis for the facility design and ultimately dictate the production capacity. The designer and the owner must work together to set realistic values for each of these design criteria. The key to designing an efficient facility with minimal equipment operational costs and capital expenditure is to provide a sufficient, but not excessive, safety factor when setting key design criteria and in specifying equipment sizes. Too small a safety factor may reduce the initial capital cost but will result in restricted operational flexibility, which in turn may mean that production and business plan goals cannot be met. Too large a safety factor will result in a facility that provides abundant operational safety, but with unnecessarily high capital and operating costs. Care should be taken to avoid the compounding of many small safety factors, applied to each design criterion, which may result in the unintentional exaggeration of facility size. The experienced designer will selectively apply safety factors to account for flexibility in production planning, variations in genetic stock quality, and potential production mishaps.



**Advanced fish handling equipment, such as counters, graders and fish pumps, may significantly reduce the labour costs of fish handling.**

and profitability. The success of a facility ultimately requires defining this balance at the business planning stage, and using it as a guideline throughout the design process.

The balancing act begins at the initiation of the project when size and production capabilities are first decided. Design criteria such as system volume, culture density, and feed rates, to name a few, form the basis for the facility design and ultimately dictate the production capacity. The designer and the owner must work together to set realistic values for each of these design criteria. The key to designing an efficient facility with minimal

Aquaculture facilities should be designed to optimize production efficiency, which involves minimizing the cost-of-production (COP). The COP for a facility is the total cost, inclusive of amortized capital costs, incurred in producing a unit weight of fish. It is a measure of the efficiency of the facility and when compared to market prices for the fish, is a direct measure of its profitability. COP can be optimized by increasing production relative to operating costs, or by decreasing operating costs relative to production.

Operating costs are those required to maintain the operation of the facility such as those for feed, energy, labour, and other consumables. Reductions in operating costs can often be achieved at the expense of higher up-front capital costs for equipment or processes. For example: more costly equipment may be selected for lower power requirements, superior efficacy, or minimized labour and maintenance requirements. The actual design of a facility may reduce labour costs through well planned layouts that provide easy access

to equipment, or through integration of fish handling and automated inventory control systems. Feed consumption may be optimized by the use of automated feeding systems. With each incremental improvement to COP, there is a compromise to be made in terms of increased capital cost. Such design decisions should be made in the context of total cost to the facility owner. While capital costs are one-time expenditures, operating costs are recurring and apply throughout the productive life of the facility.

Improved COP may also be achieved by maximizing production with the resources available. This is typically achieved by adopting more advanced production management techniques, or by designing for improved culture control. Advanced water conditioning and control systems can be used to optimize water quality and, in so doing so, improve control over culture conditions. However, there are always costs, both operating and capital, to improving system control. The designer must balance the benefits of increased production or improved fish quality against these additional costs. However, with careful planning, and the selective addition of equipment and processes that improve system control, a lower total cost of production may be achievable despite the increased expense of such systems.



**Back-up power and equipment redundancy may provide a lower overall cost in the form of decreased risk to production.**

**T**his balance between production efficiency and cost is often most apparent in intensive recirculating aquaculture systems (RAS) where the control of culture conditions is maximized. Such systems are characterized by greater technical complexity, higher capital costs, and higher operating costs for both labour and energy, than flow-through or static systems. However, because they allow optimum culture conditions to be maintained year round, independently of fluctuations in water supply, quality, and ambient temperatures, fish growth rates may be accelerated allowing more or larger fish to be produced in the same space and time. In a well-designed recirculating system, the benefits of increased production will outweigh the additional operating costs, resulting in a net lower COP to the owner. Improved control of culture conditions may also allow a facility to meet an out-of-season market demand, or to produce a higher-quality product that may be sold for a premium price, justifying the additional costs of control.

Improved control, particularly to the extent of full water recirculation, is not always required, and the choice of adding complexity and costs to the system design should be made selectively. Intelligent design choices

will optimize benefits to costs, and will reflect both the production requirements of owner's business plan and the water quality requirements of the fish. Sometimes "good enough" is the best solution.

Besides operating- and capital costs, there is a third, less defined class of costs to be considered when designing an aquaculture system. These are the costs of lost production or lost profits due to disease, or poor product quality, which in turn may be caused by mechanical failure, degraded water quality, poor operational control, or management-related issues. These are risk-related costs. Risk to a facility may come in the form of compromised biosecurity, mechanical or electrical failure, or operator error. Biosecurity risks may be mitigated through improvements to disease firewalls such as the addition of disinfection systems. The potential for mechanical and electrical failures may be addressed through equipment- and power supply redundancy. Losses due to operator error may be minimized through designed ease of operation, and by splitting large systems into smaller, more easily controlled modules. However, each additional level of protection will bear with it an incremental increase in both capital- and operating costs. The designer must weigh the benefits and costs of improved risk management and determine an acceptable level of risk tolerance. The design must then reflect the agreed balance between risk assumption and its cost. The question

to be answered is: What is the cost of lost production through mechanical failure or compromised biosecurity, or lost market opportunities due to inadequate production or product quality? The equipment or procedures that will solve those issues may seem expensive, but the total cost is actually quite low.



**Heating systems will improve control over culture conditions and fish growth rates but with higher fuel costs.**

Aquaculture system designers are left with a series of choices that can only be made through compromises. The relative importance of operating cost, capital cost, and risk management in design decisions will vary with each facility according to the project

business plan and the design preferences of the owner. Achieving the right balance among these objectives will determine the success of the design, and will ultimately provide the basis for operational success of the facility.

*KC Hosler P.Eng. (BC) is a Senior Engineer with PRAqua Technologies Ltd. Nanaimo, British Columbia. He can be reached at: +1 250 714 0141, by e.mail at: kc@pr aqua.com, website: www.praq ua.com.*